

Sources of salmonella contamination in pig processing

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Abstract

The quantification of current state of the art on alternative/novel pig slaughtering and processing procedures and pork decontamination was the initial aim of a project to reduce salmonella in pig processing for the UK Foods Standards Agency. To achieve these aims a survey of current commercial processing conditions was carried out, the published literature reviewed, and a review performed of technology from other sectors.

The main consensus of industrial opinion gleaned from the plant visits suggests that contamination comes from the live animals and the main cross-contamination issues in the abattoir are in the lairage, some scald tanks and polishers. The main cross-contamination issues in the evisceration line are considered to be in handling and inadvertent gut rupture.

In the published data there is general agreement that the main source of bacterial contamination on a meat carcass is from the animals themselves. There are comments in the literature that 70% of carcasses contaminated with salmonella are derived from carrier pigs and the remaining 30% are from cross-contamination from other sources. The main sources of cross-contamination are the skin and hooves of the animal; faeces voided by the animals; bacteria derived from the opened gut; and soil, dust, etc., carried to the killing-floor. Some researchers, however, believe that a degree of the initial contamination may be airborne. There is conflicting evidence as to the role and importance of different processing steps.

The results from all these studies have been analysed and a number of brainstorming sessions carried out to identify

1. The processes that are the main source of salmonellae contamination, and;
2. Areas where further work is likely to have the largest impact.

Survey of literature

In the published data there is general agreement that the main source of bacterial contamination on a meat carcass is from the animals themselves. At the point of slaughter, the musculature of the animal is effectively sterile and initial contamination occurs on the exposed surface. There are comments in the literature that 70% of carcasses contaminated with salmonella were derived from carrier pigs and the remaining 30% were from cross-contamination. The main sources of cross-contamination are the skin and hooves of the animal; faeces voided by the animals; bacteria derived from the opened gut; and soil, dust, etc., carried to the killing-floor. Two main routes of contamination have been identified:

1. Deposition of bacteria scattered in the air and splashing with contaminated faeces, etc.
2. Contact with dirty instruments, hands, clothes, etc.

Most authorities consider contact to be the primary route. Some, however, believe that a degree of the initial contamination may be airborne.

The difficulty of identifying the importance of different processing stages on contamination of specific bacteria, such as salmonella, may be illustrated by the study reported by Thorberg & Engvall (2001). Five Swedish pig abattoirs were visited six times, and sampling was done repeatedly at specific points in the slaughter line during the day. Both sampling of pork carcasses and the slaughterhouse environment was carried out. During the study, a total of 3,388 samples

from the five slaughterhouses were collected and cultured for *Salmonella*. All of the samples were culture negative for *Salmonella*.

A number of authors recommend the separation of incoming pigs from salmonella-positive and -negative herds, and separate slaughtering, preferably on separate days (Wong *et al.*, 2002). Animals can become clearly contaminated externally and infection spread during transport to the abattoir and during lairage. Many authors recommend withholding feed for 3-6 hours before transport to reduce faecal excretion, and limiting the time in transit and lairage to reduce spread of entero-pathogens (e.g. salmonella) (Galland, 1998).

It is clear that the sides and floor of the killing area can accumulate dirt, faeces and body fluids. Immediately after stunning carcasses are allowed to fall onto the floor or into a chute. The floor or sides of the chute may act as a means of transferring contamination. Few actual studies on pork have identified how important this contamination may be. One of the few (Bolton *et al.*, 2002) showed it to be the most significant stage of production in relation to the incidence of salmonella spp.

The speed and efficiency of stunning and bleeding may effect the contamination of pig carcasses. The more rapid and efficient it is, the quicker the blood circulation will stop and thus potentially there will be less risk for the scald water entering the system, via the cut, to reach all the tissues (Troeger, 1994).

Washing animals before scalding to reduce soiling of scald water has been recommended by a number of authors, but studied by surprisingly few. The dehairing process, whatever range of steps it uses, currently has been solely designed from a non-microbial product quality standpoint. Process steps and conditions are designed to facilitate the removal of hair and produce a rind with the required organoleptical properties. Plugging or bagging the anus to prevent the escape of faeces into scalding water, or during dehairing, scraping or polishing, has been recommended in a number of reports (Richmond, 1991; Wong *et al.*, 2002). Similarly tying the oesophagus to prevent spillage from the rumen would appear to be a potential method of reducing contamination during these processes. Neither of these operations have been widely studied. In general, a reduction in bacteria counts is achieved during the scalding operation. However, the subsequent dehairing operation often leads to recontamination and higher bacteria numbers. This appears to be due to faeces and gut fluid voided from the carcass during the operation and by cross-contamination of this detritus as it accumulates and is recirculated in the machine (Gill & Bryant, 1993; Korsak *et al.*, 2003). It has been recommended that the water in dehairing machinery should be at 60-62°C to reduce carcass contamination (ICMSF, 1998). However, it has also been reported that using water at about 60°C in the dehairing machines may cause the skins of carcasses to become flaccid and prone to being torn by the dehairing flails (Gill & Bryant, 1993). Chemically treating the water has also been recommended by some to reduce bacterial build up in the water.

Singeing has been identified by many studies as the most important operation for reducing microbial contamination, including salmonella. It is the last operation, after scalding, that actually reduces contamination. However, the exact effects of the operating conditions (temperature, treatment, duration etc.) on bacterial reduction appear to be unknown. There appears to be evidence that bacteria may be protected in folds, orifices or hair follicles and be spread in the subsequent polishing operation, but this is not clear. In contrast polishing has been identified by many reports as the most important operation for the recontamination of pork carcasses following the reduction that occurs during singeing. However, is it not clear whether it has a particularly important role in salmonella recontamination. Polishing systems are very hard to clean and by the end of the day they can be transferring large numbers of bacteria to the surface of the carcass.

Pre-evisceration washing with hot water appears to be successful at reducing microbial contamination. A 20 s deluge wash at 85°C has been reported to reduce the levels of spoilage organisms and *E. coli* on pork carcasses by 2.5 log₁₀ cfu cm⁻² (Gill *et al.*, 1995). It is not clear what proportion of salmonella contamination on a carcass are from surface bacteria that have survived on the surface since polishing and what proportion arise during evisceration. Some authors have stated that evisceration is the single most important source of contamination. Published data appears to indicate that evisceration does not have a significant effect on total aerobic bacterial numbers. However, it does appear to have a significant effect on Enterobacteriaceae and salmonella numbers. In reviewing evisceration, Berends *et al.* (1996, 1997) concluded that

approximately 60-90% of the total carcass contamination with *Salmonella* spp. occurs during evisceration, while splitting, fat trimming and meat inspection together may contribute between 5-35%. However, other authors contend that provided the correct precautions are taken – the anus and oesophagus are closed and the gut is not punctured – evisceration will cause little contamination.

Berends *et al.* (1998) came to the conclusion that the "most efficient and cost-effective way of reducing the 'Salmonella problem' entailed by the consumption of pork would be to decontaminate carcasses" pre-chilling providing "the entire production chain strictly adheres to GMP principles". Although chilling is not usually considered a method of decontamination, it does have an important role in reducing bacterial multiplication. In many cases, intervention treatments are believed to extend the lag phase of the bacteria of interest. If the surface temperature of the meat is then cooled to below the organism's minimum growth temperature before the lag phase expires, then bacterial growth will not occur.

Key areas for further work

In parallel to the literature review a large survey current practices and operations in UK pig abattoirs was carried out. Some details of the results of the industrial survey are presented in this symposium (Tinker *et al.*, 2007). However, in addition at all the abattoirs visited the operators were asked which of their current operations they felt were an important source of salmonella distribution and required further research or development. They were asked to rank them as of high, medium or low importance. A similar exercise was carried out on data from the literature review and a composite table produced to guide the next stage of the investigations (Table 4).

Table 4. Rating (H = High, M = medium and L = low) of importance of an operation as a contamination route and worthy of further research.

	Are the following an important contamination route and/or worthy of more research?	Literature	Industry
1	Current lairage design and operation	H	H
2	Escape of faeces	H	H
3	Current polishing processes	H	H
4	Existing evisceration processes	H	H
5	Dehairing processes	M	M
6	Lack of decontamination interventions pre-evisceration	M	M
7	Current late removal of pigs head	H	L
8	Lack of decontamination interventions pre-chill	M	M
9	Current operation of derinder	M	M
10	Lack of pre-scald wash	M	M
11	Cleanliness of grambling tables	H	L
12	Current scalding operations	M	L
13	Current sticking operations	M	L
14	Current chilling operations	M	L

Work required

All the data gathered was analysed at a number of brainstorming sessions and the following areas in chronological order of processing that were felt to have the most potential identified:

Scheduling:

A rapid method of identifying salmonella-positive herds is required so that +ive and -ive groups can be separated.

Lairage:

Develop an automatic lairage floor scrubber, tactilely guided by walls.

Scalding, singeing and polishing:

Investigate 100°C steam scald which would use full latent heat potential of steam.

Investigate ultrasonic water baths for a combined dehair and scald.

- Develop a non-damaging and easy to implement anus bunging systems.
- Investigate faeces sucking to clear rectal passage before scald.
- Investigate application of alternative dehairing concepts abrasion, epilation, etc.
- Investigate a full singe dehairing process.
- Investigate replacing flail/whip type wet polisher with high pressure water jets.

Evisceration:

- Development of a non-damage and easy to implement throat bunging system.

Develop local washing/cleaning techniques for pertinent areas on the carcass surface (such as belly opening cut line, or around anus, etc).

Interventions:

- Develop heat based pasteurization methods for eviscerated, split carcasses.

- Investigate final toast on outer surface immediately prior to chilling.

Work is now ongoing in many of the areas identified both in the laboratory and with industrial producers to minimise salmonella contamination of pig carcasses and subsequent food poisoning.

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